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MOVEMENT, ABUNDANCE, AND LENGTH COMPOSITION OF BURBOT IN RIVERS OF INTERIOR ALASKA DURING 1989[1]

By

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ABSTRACT

In an ongoing study of burbot *Lota lota* in rivers of interior Alaska, five sections of the mainstem Tanana River, one section in each of five Tanana River tributaries, and one section of the Yukon River were sampled between 13 June and 29 August, 1989. Sampling in all sections was conducted using commercially manufactured hoop traps set at near equal intervals throughout each section. All traps were rebaited and moved daily for a period of four days. All sections of the Tanana and Yukon rivers were 64 kilometers in length, while sections of Tanana River tributaries were 32 kilometers in length.

Relative densities, based on mean catch-per-unit of effort estimates (burbot per net-night) for burbot fully recruited to hoop trap gear (450 millimeter total length and larger), were obtained for each section as an index of abundance. In sections of the mainstem Tanana River these estimates ranged from 0.19 to 1.22. Mean catch-per-unit of effort in tributary streams ranged from 0 to 0.99, while catch-per-unit of effort in a section of the Yukon River was 0.25. Comparisons of catch-per-unit of effort estimates obtained in 1988 and 1989 in a section near Fairbanks were not significantly different, indicating that the relatively large harvest which occurred in this area did not have a detrimental effect on local stocks.

Mean total lengths of fully recruited burbot sampled in the Tanana River were similar in all but one section and ranged from 412 to 533 millimeters. Burbot sampled in the Yukon, Tolovana, Chena, and Chisana rivers were generally larger than those sampled in the Tanana River, while burbot sampled in the Kantishna and Goodpaster rivers were generally smaller. Length frequency distributions of burbot sampled in the Fairbanks area during 1988 and 1989 were similar, also indicating that harvest in this area did not have a detrimental effect on local stocks.

Information concerning movements of burbot throughout the Tanana River drainage was based on 630 tag recoveries obtained through sampling and from anglers since the study began in 1983. Relative mixing rates of burbot throughout the system have shown there is movement of burbot throughout the length of the mainstem Tanana River and between tributary streams and the mainstem Tanana River, indicating burbot in this system are of a single stock. Movement data also indicates that a high proportion of burbot remain resident to the area in which they were tagged between sampling events. This proportion is lower after two or more years from tagging date, which implies that burbot are not resident to an area throughout their lifetime. Proportions of movements during the period from river freeze-up to time of spawning were higher than during other times of the year, indicating there are seasonal migrations to spawning areas and a return migration to oversummer areas. These spawning migrations coincide with the period when most of the sport fishery harvest occurs minimizing local stock depletion.

KEY WORDS: burbot, *Lota lota*, Tanana River, harvest, hoop trap, catch-per-unit of effort, mean length, Relative Stock Density, seasonal movements, annual movements, relative mixing rates, management.

INTRODUCTION

Burbot *Lota lota* are a popular sport fish species with interior Alaska anglers. Annual harvests in flowing waters of the Tanana River drainage in recent years have averaged nearly 4,000 burbot, and account for about 23% of the statewide harvest (Mills 1989). The bulk of this harvest comes from waters of the mainstem Tanana River and the Chena River (Figure 1). In the Tanana River and its tributaries, the fishery occurs year-round throughout the entire system. However, a concentrated effort occurs in the winter months near the community of Fairbanks. As much as 64% of the total annual harvest drainage-wide occurs in this area. Baited set-lines are the primary gear used although hand held lines are used as well. The Tanana River system is renowned for its trophy-sized burbot. Nearly two-thirds of the trophy fish certificates[1] issued in Alaska since 1967 have come from flowing waters of the Tanana River drainage.

Current regulations allow for a 15 burbot daily bag and possession limit, with use of up to 15 baited hooks. Although harvest levels have remained stable and low over the past ten years relative to the large abundance of burbot in this system, the potential for a dramatic increase in harvest exists with these regulations. Because burbot in northern climes are known to be relatively long-lived, slow growing, and late maturing (Chen 1969; Evenson 1988), they are susceptible to overexploitation. Prior to 1983, little was known about stock structure or biological characteristics of burbot in this large system, thus it was not known if harvest levels were exceeding sustainable yield.

Beginning in 1983, the Alaska Department of Fish and Game (ADFG) initiated a stock assessment program to investigate migratory behavior, examine life history characteristics, and estimate relative abundance of burbot throughout the Tanana River drainage. The long-term goal of this research is to define stock structure and determine sustainable yield for these stocks. This report summarizes the findings of this study during 1989 and updates information provided by Evenson (1989). Specific objectives of this study during 1989 were to:

1. estimate an index of abundance (mean catch rate by overnight set of a hoop trap) of all burbot 450 mm TL and longer in each of 11 sample sections;

2. estimate the mean length of all burbot 450 mm TL and longer in each of 11 sample sections;

3. test the hypothesis that burbot do not migrate between the Tanana and Yukon rivers; and,

4. test the hypothesis that burbot do not migrate from the Tanana River into the Kantishna River.

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[1] Data is taken from the Trophy Fish Program sponsored by the Alaska Department of Fish and Game Division of Sport Fish. Trophy fish certificates are given for burbot weighing 8 pounds or more.

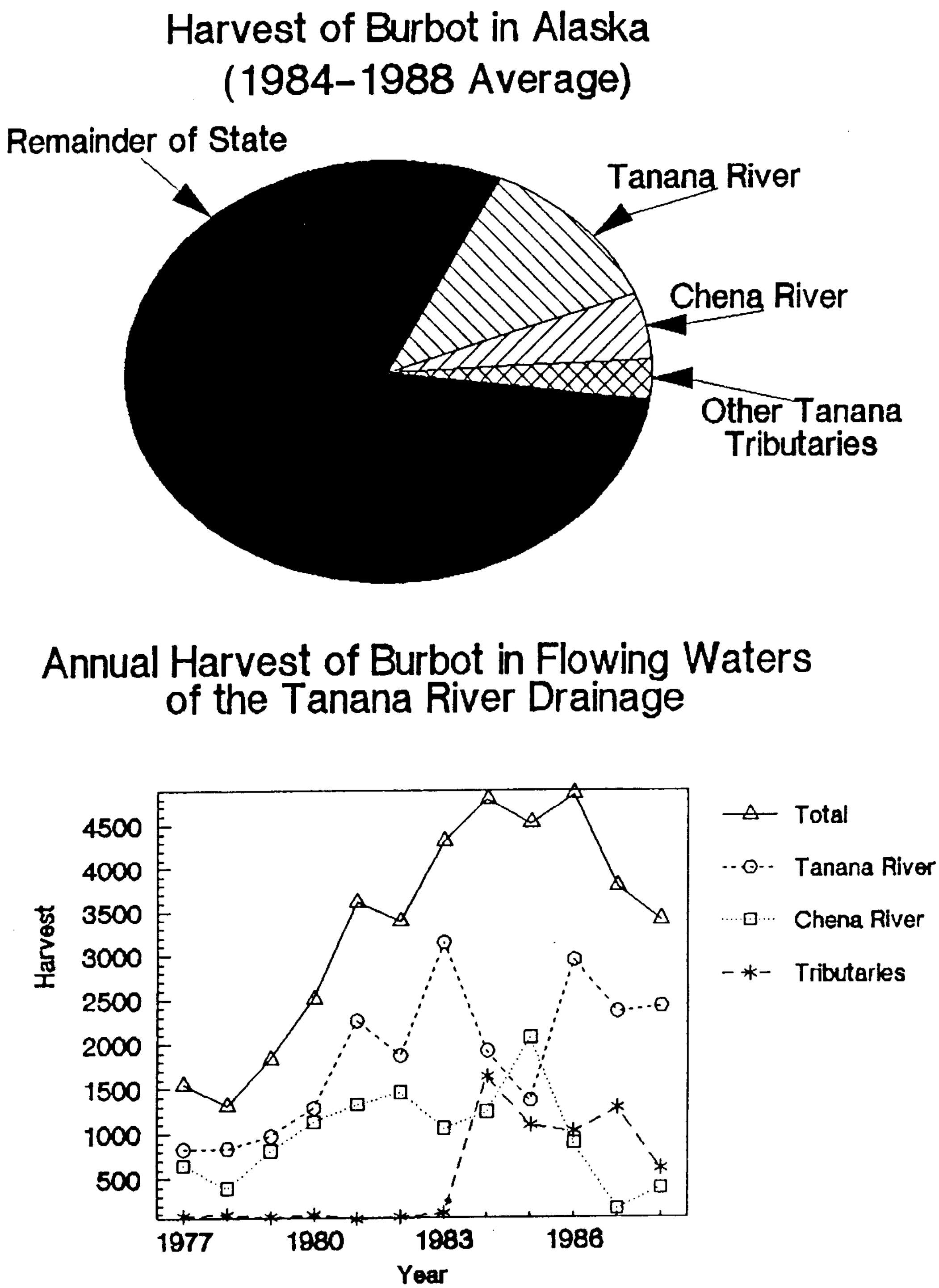

Figure 1. Harvest of burbot in the Tanana River drainage.

Objective (3) is the first year of a two year study. Objective (4) is the second year of a two year study.

In addition, information obtained from tag recoveries was used to estimate relative mixing rates of burbot between 10 sections of the Tanana River and three tributary rivers, and to estimate seasonal and annual movement rates of burbot in the Tanana River.

STUDY AREA

Tanana River

The Tanana River is a large, silt-laden river of glacial origin formed at the confluence of the Chisana and Nabesna rivers near Northway, Alaska. From its origin, the Tanana River flows northwesterly for 912 km where it drains into the Yukon River, approximately 6 km east of Tanana, Alaska (Figure 2). Tributaries flowing from the south are primarily glacial-fed streams flowing from the Alaska Range and Wrangell Mountains, while northern tributaries are primarily clear runoff streams flowing from the Tanana-Yukon Uplands. Burbot are found throughout the system. During 1983 and 1984 sampling was conducted in one section near Fairbanks. During 1985 sampling was expanded and included seven sections located between Fairbanks and Delta Junction. From 1986 through 1989 sampling was expanded further with sample sections ranging across the entire river. During 1989 five sections 64 km in length were sampled (Figure 3).

Tanana River Tributaries

Five tributary streams of the Tanana River were sampled during 1989. Each river was sampled beginning at its confluence with the Tanana River extending upstream approximately 32 km. These tributaries included the Kantishna, a large glacial fed river flowing from the south; the Tolovana, Chena, and Goodpaster rivers, clear-water runoff rivers flowing from the north; and the Chisana River, a glacial fed headwater river (Figure 2). The Tolovana, Chena, and Chisana rivers had been sampled in previous years, while the Kantishna, and Goodpaster rivers had not.

Yukon River

One section of the Yukon River was sampled during 1989 beginning 64 km downstream from the confluence of the Tanana River extending upstream to the confluence of the Tanana River (Figure 2). One section of the Yukon River had been sampled previously in the vicinity of the Dalton Highway Bridge.

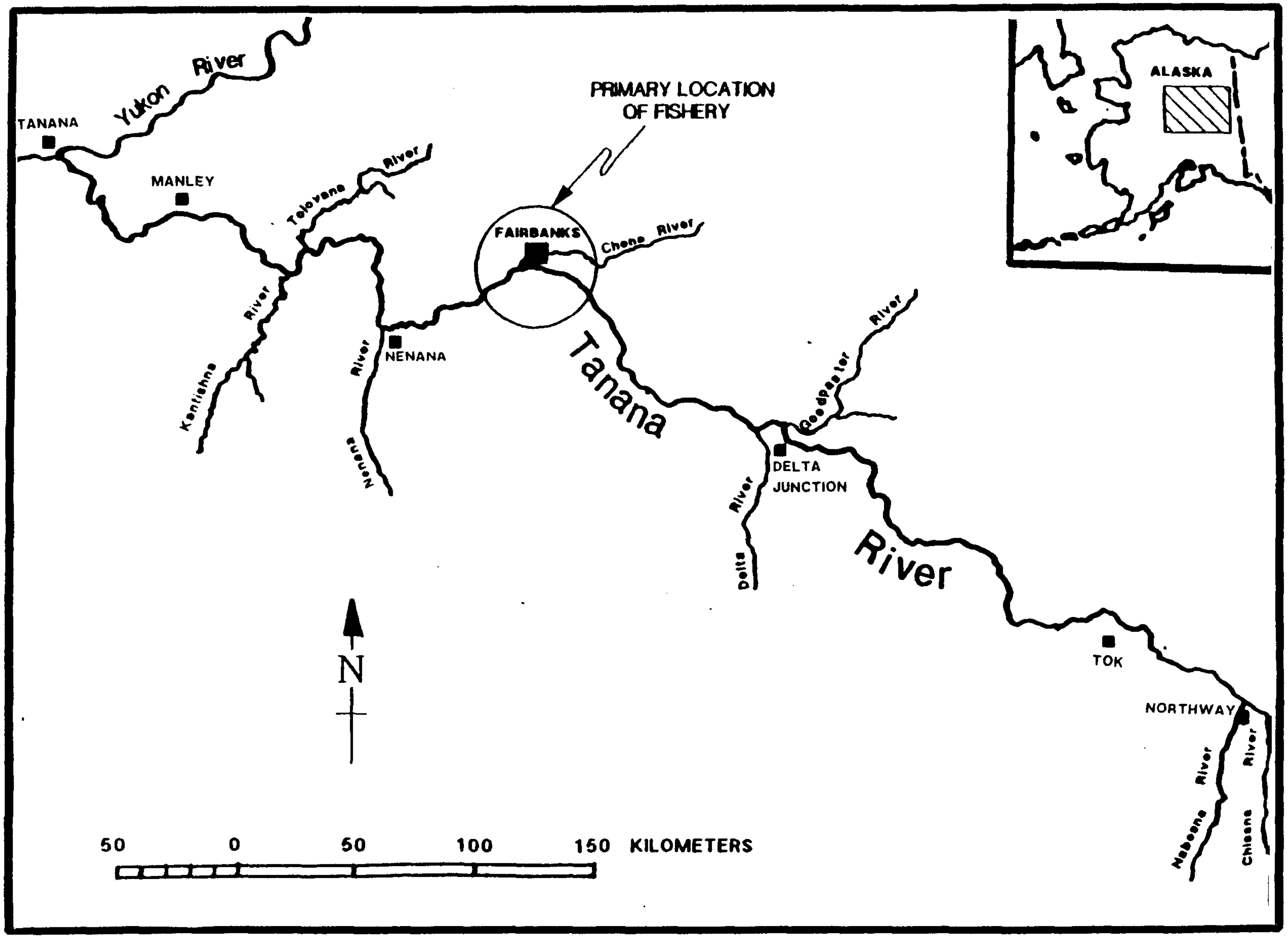

Figure 2. Map of the Tanana River drainage.

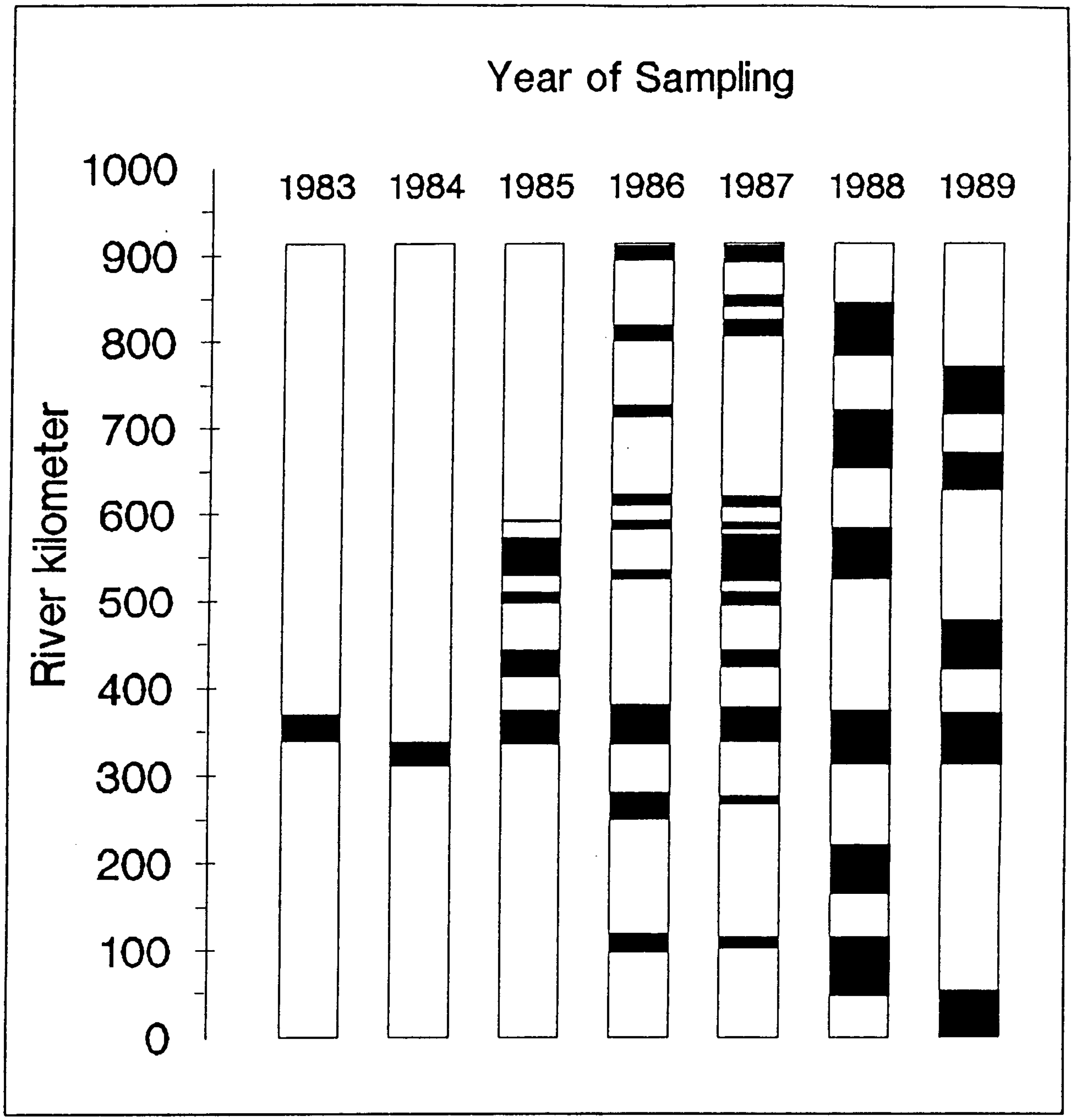

Figure 3. Relative locations of sample sections (shaded areas) in the mainstem Tanana River from 1983 through 1989.

METHODS

Gear Description

Burbot were captured in two sizes of commercially manufactured hoop traps. The type of trap used during 1983 through 1987 was constructed with knotted nylon netting woven into 25 mm bar mesh attached to seven fiberglass hoops. Traps were 3.66 m long and 0.91 m in diameter. Each trap had a double throat (tied to the first and third hoop) and was kept stretched with two spreader bars made from PVC pipe with snap clips on each end which were attached to the end hoops.

The second type of trap was used experimentally in two subsections during 1987, and was used for all sampling during 1988 and 1989. The trap was designed as above, but was smaller. These traps were 3.05 m long with 7 mm steel hoops tapering from 0.61 m diameter at the entrance to 0.46 m at the cod end. Spreader bars were constructed of 12 mm galvanized steel conduit (Figure 4).

Both sizes of traps are selective for burbot larger than 449 mm TL, and the smaller traps are less effective at capturing large burbot (greater than 800 mm TL) than are larger traps (Bernard et al. In press). The smaller traps were selected for use during 1988 and 1989 because they are easier to handle, they are smaller and lighter thus more can be carried in a boat, and they are less expensive than the larger traps.

The hoop traps were baited with cut Pacific herring *Clupea harengus* placed in perforated plastic containers. One end of a 5 m to 10 m section of polypropolene rope was tied to the cod end of each trap, while the other end was tied off to shore. The traps then fished on the river bottom near shore with the opening facing downstream. An outboard-powered riverboat was used to set, move, and retrieve the traps.

Study Design

All sampling of burbot from 1983 through 1987 was conducted in the mainstem Tanana River. Subsections typically were 16 km in length. In 1988 subsections were lengthened to 64 km and sampling included subsections in the Yukon, Tolovana, and Chena rivers. During 1989, subsections in the Tanana and Yukon rivers were 64 km in length, while subsections in the Kantishna, Tolovana, Chena, Goodpaster, and Chisana rivers were 32 km in length. The larger sections were sampled with two crews of two persons each, while the smaller sections were sampled with one, two person crew. All sampling was conducted during open water periods between 1 June and 15 October.

For each of the subsections sampled during 1983 through 1989, traps were typically set for a period of 24 hours at a density of three to six traps per kilometer. Traps were set at near equal intervals along both shores depending on availability of suitable setting locations and were moved each day to a new location within the subsection. A trap site was deemed suitable if water velocities were low and did not float the trap, if the water was at least 0.5 m deep, and if the area was free of debris. All sections were sampled for

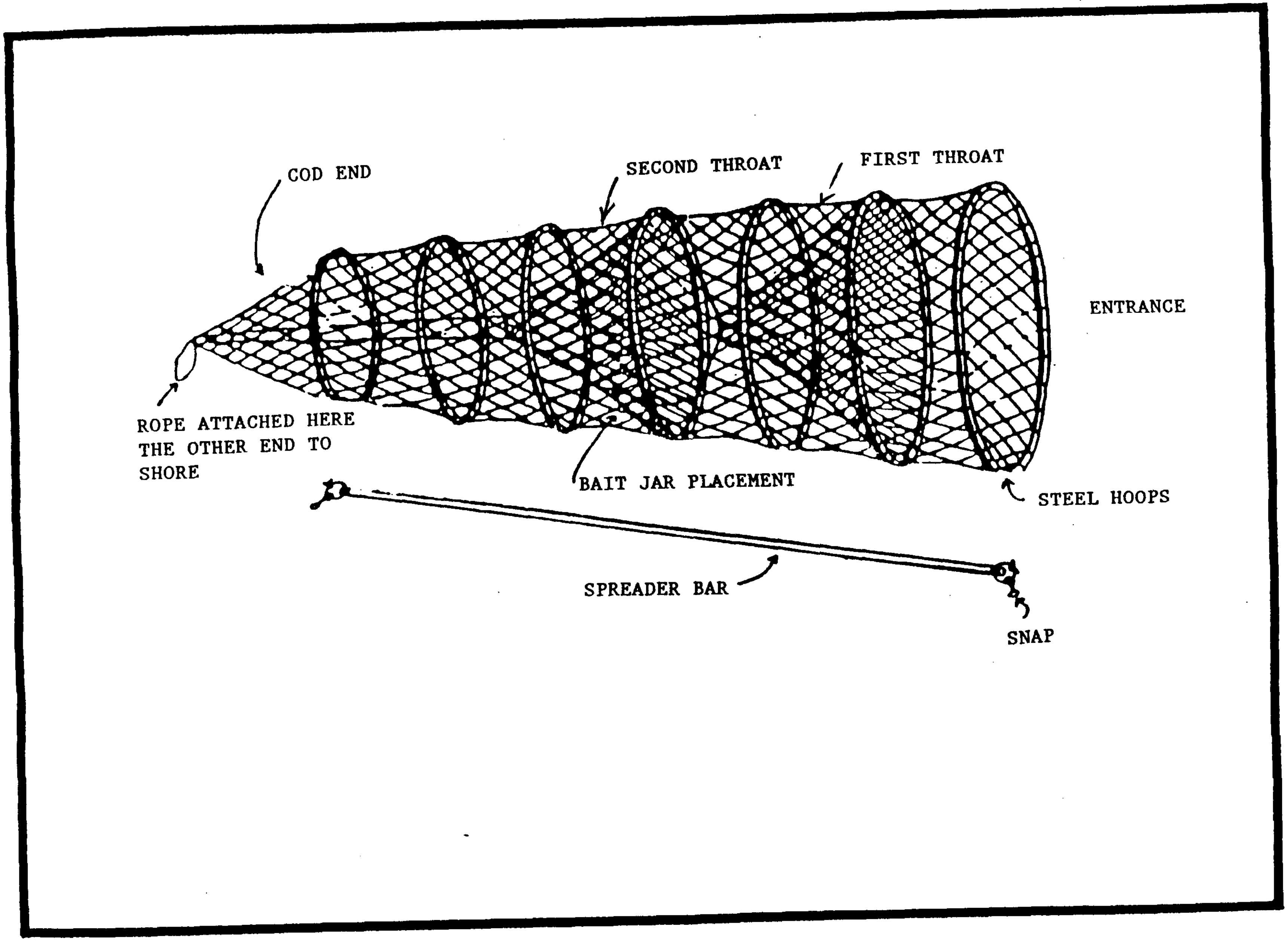

Figure 4. Diagram of hoop trap gear used to capture burbot.

a period of four days. All trap locations were marked on 1:63,360 USGS maps and were recorded to the nearest river kilometer (river kilometer 0 was assigned to the mouth of the river being sampled). All burbot captured were measured to the nearest millimeter, tagged using individually numbered Floy internal anchor tags, fin-clipped (right and left pelvic clips were alternated from one year to the next), and released at the capture sight. Recaptured burbot were obtained through sampling and from anglers.

Catch-per-Unit of Effort

Estimates of mean catch-per-unit of effort (CPUE), defined as the mean number of burbot captured per net-night during each sampling period, and its associated variance were calculated based upon the following equations from Wolter (1984):

$$\overline{CPUE} = \overline{X} = n^{-1} \sum_{s=1}^{t} X_{ch}; \tag{1}$$

$$V[\overline{CPUE}] = \frac{\sum_{s=2}^{t} [X_{ch} - X_{ch-1}]^2}{2t[t-1]} \tag{2}$$

where:

X_{ch} = catch of burbot of a size class c in hoop trap h;

t = the total number of effectively fishing hoop traps in a river section; and,

s = the set number such that s = 1 to t in order with i = 1 the most downstream set and i = t the most upstream.

Mark-recapture experiments conducted in the past (Evenson 1988; Parker et al. 1988) have shown that burbot become fully recruited to hoop traps after they have grown beyond 449 mm TL. For this reason separate estimates of mean CPUE were made for small burbot (< 450 mm TL) and large burbot (450 mm TL and larger).

Density distributions (based on CPUE) of fully recruited burbot throughout the mainstem Tanana River were analyzed by comparing mean CPUE in each of the five river sections sampled during 1989 using a Kruskal-Wallis test. The same comparison was made for six different river sections sampled during 1988.

Mean CPUE was also compared in one river section near Fairbanks (river kilometer 317 to 374) between 1988 and 1989 using a Mann-Whitney test. One estimate was obtained each year.

Length Frequency

For the same reason described above concerning full recruitment to hoop traps, estimates of mean length were made for only those burbot 450 mm TL and longer. Estimates of mean length and its associated variance for all captured burbot ≥ 450 mm TL and for all sample sections were:

$$\bar{l} = \sum_{b=1}^{n} \frac{l_b}{n}; \tag{3}$$

$$V[\bar{l}] = \sum_{b=1}^{n} \frac{(l_b - \bar{l})^2}{n(n-1)} \tag{4}$$

where:

l_b = length of burbot b; and;

n = number of samples.

Lengths of burbot fully recruited to the gear (> 449 mm TL) were compared between river sections using a Kruskal-Wallis test. Multiple comparison tests (Conover 1980) were used to evaluate differences in length distribution between pairs of river sections.

Minimum length categories for Relative Stock Densities (RSD) were defined after review of Gabelhouse (1984). The RSD's were calculated for all sample sections as the proportion of all burbot 300 mm TL and longer within a defined category. All burbot < 450 mm TL were placed into one category. Variances for these estimates were calculated as:

$$V[\hat{F}_x] = \frac{\hat{F}_x(1-\hat{F}_x)}{n_k - 1}; \tag{5}$$

where: $\hat{F}_x$ = estimated proportion of sampled fish k within a defined length class x.

Length frequency distributions of burbot captured in the Fairbanks section (river kilometer 317-374) during 1988 and 1989 were compared with a Kolmogorov-Smirnov two sample test. The RSD for these sampling events were calculated to determine which length categories, if any, differed between years.

Movement

Movement data from 630 recaptured burbot obtained through sampling and from anglers from 1983 through 1989 consisted of distance travelled (river kilometers upstream or downstream) and days of freedom between mark and recapture dates. Much of this information was reported in Evenson (1989). During 1989, 37 recaptured burbot were obtained through sampling efforts and 32 were obtained from anglers. This report summarizes movement information provided by Evenson (1989) and updates this information with recapture data obtained during 1989. Data analysis includes estimation of relative mixing rates between ten sections of the Tanana River and three tributary rivers, as well as annual and seasonal movement rates of burbot throughout the Tanana River.

Relative mixing rates of burbot throughout 10 sections of the Tanana River and four tributary rivers were determined using multinomial proportions based on all burbot recaptured since 1983. By considering only recaptured fish, grouping of data across years is permitted. Also, this restriction makes valid any comparison of proportions dependent on a single assumption: equal probability of capture of tagged burbot among river sections in the same year. Because traps were set at near equal density along the river in all sections, this condition was satisfied.

The marginal proportions in this multinomial distribution were calculated from the following equations in Cochran (1977):

$$\hat{Q}_{ij} = \frac{r_{ij}}{r_i}; \qquad (6)$$

$$\hat{V}[\hat{Q}_{ij}] = \frac{\hat{Q}_{ij}(1 - \hat{Q}_{ij})}{r_{i.} - 1} \qquad (7)$$

where:

$r_{i.}$ = the number of burbot marked in section i;

r_{ij} = the number of burbot marked in section i and recaptured in section j; and,

$\hat{Q}_{ij}$ = the relative mixing rate of burbot tagged in section i and recovered in section j.

A border rule was set up whereby a burbot must travel greater than 10 km to be considered significant movement into another river section.

Annual and seasonal movement rates were calculated as proportions of all recaptured burbot 1) moving downstream (11 km or more); 2) remaining resident (moving upstream or downstream 10 km or less); 3) moving slightly upstream (11 to 50 km); 4) moving moderately upstream (51 to 100 km); and, 5) moving extremely upstream (101 km or more).

Annual movement rates considered only those burbot captured during a sampling period (a sampling period occurs during June, July, August, and September). One year was defined as the time between one sampling period and the next year sampling period. Tag recoveries obtained through sampling as well as from anglers were considered in these calculations.

Seasonal movement rates considered only those burbot recaptured within one year from a sampling period. These calculations also included both sampling and angler tag recoveries. Seasons were defined as 1) open water (15 May through 15 October); 2) freeze-up to spawning (16 October through 31 January); 3) spawning to breakup (1 February through 14 May); and, 4) open water to next year open water.

Two objectives of this study were to determine whether burbot migrate between 1) the Tanana and Kantishna rivers; and, 2) between the Yukon and Tanana rivers. These objectives were designed as two-year studies in which a marking event would be conducted in River A (Tanana River in the former and Yukon River in the latter) during the first year, and a recapture event would be conducted in River B during the second year (Kantishna River in the former and Tanana River in the latter). The marking event for Case 1 began in 1988 when 590 burbot were marked in the Tanana River in sections nearby the confluence of the Kantishna River. The marking event for Case 2 began in 1989 in the Yukon River nearby the confluence of the Tanana River. Hypothesis testing for these experiments assumed a 75% annual survival rate[2], a probability of capture[3] equal to 0.00033, and a 10% interchange as a threshold of stock delineation. With this criteria, 215 burbot needed to be captured and examined for tags in the Kantishna River during 1989 to be 95% sure of capturing one burbot which had migrated from the Tanana River. Concurrently, 290 burbot were expected to be captured and marked in the Yukon River. Then, 280 burbot would need to be captured in the Tanana River during 1990 to be 95% sure of recovering one burbot which had migrated from the Yukon River.

RESULTS

Catch-per-Unit of Effort

Estimates of mean CPUE for fully recruited burbot in five sample sections of the Tanana River were dissimilar ($P < 0.01$), and ranged from 0.19 in the Salcha section (river km 418 to 474) to 1.22 in the Johnson section (river kilometer 632 to 662). Estimates of mean CPUE for small burbot in these same sections ranged from 0.21 in the Tanana section (river kilometer 0 to 54) to 0.67 in the Salcha section. Ratios of CPUE for large burbot to CPUE for small burbot in these sections ranged from 0.3 in the Salcha section to 2.7 in the Johnson section (Table 1). Estimates of mean CPUE for fully recruited burbot in six river sections sampled during 1988 were also dissimilar ($P < 0.01$). Rates of immediate sampling mortality ranged from 7% in the Tanana section to 12% in the Salcha section.

Mean CPUE for fully recruited burbot in the six other rivers sampled during 1989 ranged from 0 in the Goodpaster River to 0.99 in the Chisana River.

[2] Based on data obtained from Parker et al. (1988) concerning annual survival rates of burbot in interior Alaska lakes.

[3] Based on data obtained by Evenson (1988).

Table 1. Catch summaries from sampling conducted during 1989 in the Tanana River.

	Tanana River Sections / (River Kilometers)				
	Tanana (0-54)	Fairbanks (317-374)	Salcha (418-474)	Johnson (632-662)	Tanacross (714-766)
Date Sampled	12-15 Jul.	13-16 Jun.	20-24 Jun.	8-11 Aug.	13-16 Aug.
Net-Nights	228	237	225	239	234
Total Burbot	139	272	183	400	245
Total Large[a] Burbot	91	131	42	292	95
CPUE[Large]	0.40	0.55	0.19	1.22	0.41
SE[$CPUE_{lg}$]	0.05	0.05	0.03	0.18	0.05
Total Small[b] Burbot	47	139	150	108	150
CPUE[Small]	0.21	0.59	0.67	0.45	0.64
SE[$CPUE_{sm}$]	0.03	0.06	0.07	0.05	0.07
$CPUE_{lg}$: $CPUE_{sm}$	1.90	0.93	0.28	2.71	0.64
Recaptures	0	13	1	18	5
Immediate Mortalities	1	12	22	6	9

[a] Large burbot are 450 mm TL and longer.
[b] Small burbot are less than 450 mm TL.

Estimates of CPUE for small burbot in these rivers ranged from 0.06 in the Yukon River to 0.29 in the Goodpaster River. Ratios of CPUE for large burbot to CPUE for small burbot in these rivers ranged from 0 in the Goodpaster River to 11.3 in the Tolovana River (Table 2). Rates of immediate sampling mortality ranged from 0% in the Chena, Goodpaster, Chisana, and Yukon rivers to 4% in the Kantishna River.

Comparisons of CPUE estimates for fully recruited burbot obtained from the Fairbanks section, one each from 1988 and 1989, showed mean CPUE during these two years was not significantly different ($P \geq 0.80$).

Length Frequency

Estimates of mean length for fully recruited burbot in five sample sections of the Tanana River were dissimilar ($P < 0.01$), and ranged from 549 mm TL in the Fairbanks section (river kilometer 317 to 374) to 588 mm TL in the Johnson section (Table 3). However, a multiple comparison test from Conover (1980) with $\alpha = 0.05$ for each two section comparison showed that mean lengths in all sections were similar with the exception of the Johnson section, which tended to contain larger fish than the other sections. Examination of RSD's in these sections revealed similar findings. Burbot in the Johnson Section were found in higher proportions of "preferred", "memorable", and "trophy" categories than in any of the other sections. Over 70% of all fish sampled in all Tanana River sections were of "stock" and "quality" lengths (Table 3).

Mean lengths of fully recruited burbot in the six other rivers sampled during 1989 were much more variable and ranged from 562 mm TL in the Kantishna River to 650 mm TL in the Yukon River (no large burbot were captured in the Goodpaster River). With the exception of the Goodpaster and Kantishna rivers, these rivers tended to contain larger fish than in the Tanana River, with most burbot found in the quality and preferred length classes (Table 3).

Length frequency distributions in the Fairbanks section from sampling done in 1988 and 1989 were similar ($0.05 < P < 0.10$), with burbot captured during 1989 slightly larger than those captured during 1988 (Table 4).

Movement

Prior to sampling during 1989, no movement of burbot into, or through, one section of the Tanana River (river kilometer 594 to 712) had been documented. This indicated the possibility of two distinct stocks occurring in the mainstream river. However, during 1989 one burbot was recovered upstream of this section which had been tagged in a downstream section, one burbot which was tagged in this section moved through to an upstream location, and one burbot which was tagged in an upstream section moved downstream into this section. This information, along with other tag recoveries, indicates there is interchange of burbot throughout the length of the river.

Of the 630 tag recoveries obtained to date, 190 (30%) were returned by anglers and 440 (70%) were obtained through sampling efforts. The longest recorded upstream movement was 366 km in 1,110 days, while the longest recorded downstream movement was 168 km in 392 days. A total of 434 tag recoveries

Table 2. Catch summaries from sampling conducted during 1989 in other rivers of interior Alaska.

	River / (River Kilometers)					
	Kantishna (0-43)	Tolovana (0-43)	Chena (0-40)	Goodpaster (0-18)	Chisana (0-38)	Yukon (242-203)[a]
Date Sampled	29 Jul.-1 Aug.		27-30 Jun	27-28 Jun.	27-29 Aug.	16-18 Jul
Net-Nights	113	121	120	58	122	170
Total Burbot	45	103	102	17	135	53
Total Large[b] Burbot	19	95	73	0	121	42
CPUE[Large]	0.17	0.79	0.61	0.00	0.99	0.25
SE[$CPUE_{lg}$]	0.03	0.09	0.09	0.00	0.13	0.05
Total Small[c] Burbot	26	8	30	17	12	11
CPUE[Small]	0.23	0.07	0.25	0.29	0.10	0.06
SE[$CPUE_{sm}$]	0.05	0.02	0.06	0.15	0.04	0.02
$CPUE_{lg}$: $CPUE_{sm}$	0.7	11.3	2.4	0	9.9	4.1
Recaptures	0	0	5	0	5	0
Immediate Mortalities	2	1	0	0	0	0

[a] River kilometers were measured downstream of the Dalton Highway Bridge.
[b] Large burbot are 450 mm TL and longer
[c] Small burbot are less than 450 mm TL.

Table 3. Mean length[a] and Relative Stock Density[b] estimates of burbot sampled in rivers of Interior Alaska during 1989.

Sample Section	Mean Length	Stock 300	Quality 450	Preferred 625	Memorable 725	Trophy 900
		Category / Gabelhouse Minimum Length (mm TL)[c]				
Tanana River						
Tanana	496	0.35	0.51	0.09	0.04	0.00
(SE)	(7)	(0.05)	(0.05)	(0.03)	(0.02)	(0.00)
Fairbanks	462	0.51	0.42	0.04	0.03	0.00
(SE)	(5)	(0.04)	(0.04)	(0.02)	(0.02)	(0.00)
Salcha	412	0.77	0.18	0.04	0.01	0.00
(SE)	(5)	(0.07)	(0.06)	(0.03)	(0.01)	(0.00)
Johnson	533	0.27	0.49	0.14	0.09	0.01
(SE)	(4)	(0.03)	(0.03)	(0.02)	(0.02)	(<0.01)
Tanacross	439	0.62	0.30	0.06	0.02	0.00
(SE)	(5)	(0.05)	(0.05)	(0.02)	(0.01)	(0.00)
Other Rivers						
Kantishna	413	0.56	0.44	0.00	0.00	0.00
(SE)	(11)	(0.12)	(0.12)	(0.00)	(0.00)	(0.00)
Tolovana	587	0.08	0.60	0.15	0.17	0.00
(SE)	(9)	(0.03)	(0.05)	(0.04)	(0.04)	(0.00)
Chena	511	0.29	0.53	0.11	0.07	0.00
(SE)	(8)	(0.05)	(0.06)	(0.04)	(0.03)	(0.00)
Goodpaster	386	1.00	0.00	0.00	0.00	0.00
(SE)	(6)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Chisana	622	0.09	0.43	0.24	0.19	0.04
(SE)	(8)	(0.03)	(0.05)	(0.04)	(0.04)	(0.02)
Yukon	583	0.21	0.42	0.21	0.11	0.06
(SE)	(18)	(0.06)	(0.08)	(0.06)	(0.05)	(0.04)

[a] Mean length was calculated for all burbot 450 mm TL and larger.
[b] Relative Stock Density expressed as the proportion of burbot sampled within a given length category.
[c] Minimum lengths for each category derived from Gabelhouse (1984).

Table 4. Relative Stock Density[a] estimates of Tanana River burbot captured in the Fairbanks section during 1988 and 1989.

Category	Gabelhouse Minimum Length[b]	1988 Relative Stock Density	1988 S.E.	1989 Relative Stock Density	1989 S.E.
Stock	300	0.53	0.04	0.51	0.04
Quality	450	0.44	0.04	0.42	0.04
Preferred	625	0.02	0.01	0.04	0.02
Memorable	725	0.01	0.01	0.03	0.02
Trophy	900	0	0	0	0

[a] Relative Stock Density expressed as the proportion of burbot sampled within a given length category.

[b] Minimum lengths for each category derived from Gabelhouse (1984).

(69%) were obtained within 10 km of the original tagging site. A total of 171 tags (27%) were collected further than 10 km upstream from the original tagging site. Of these, 141 were recovered between 10 and 100 km upstream, and 30 were recovered greater than 100 km upstream. Only 25 tags (4%) were obtained greater than 10 km downstream of the original tagging site.

Relative mixing rates of burbot throughout the Tanana River drainage varied among river sections. Proportions of burbot resident to a given section ranged from 21% (SE = 11%) in section 3 of the Tanana River (river kilometer 171 to 267) to 97% (SE = 3%) in section 7 (river kilometer 530 to 630) of the Tanana River (Table 5). These mixing rates also indicate interchange of burbot throughout the system, as well as a tendency for upstream movement. Most of the downstream movements documented are associated with movement into or out of a tributary stream.

Annual movement rates indicated that a high proportion (80%; SE = 2%) of burbot remain resident to a given area after one year from the tagging date. However, after two or more years following the tagging date, the proportion of resident burbot dropped to 61% (SE = 6%; Figure 5). The proportion of burbot migrating downstream remained relatively constant, while the proportion of burbot migrating moderate and extreme distances upstream increased substantially after two years following the tagging date.

Analysis of seasonal movements indicated that the highest frequency of movement occurred during the period between river freeze-up and spawning. The proportion of burbot remaining resident to an area was only 31% (SE = 21%) during this period compared to 82% and 80% respectively (SE = 6% and 2% respectively) during the open water period of the year of tagging and the open water period one year following tagging (Figure 6).

During sampling in the Kantishna River, a total of 45 burbot were captured and no tags were recovered. This is well below the 215 burbot which were needed to attain 95% confidence of capturing a tagged burbot which had migrated from the Tanana River. Because catch rates were well below what was expected, over 500 net-nights of effort would have been needed to attain this goal. Logistical restraints prevented further sampling of this magnitude. A similar problem arose while sampling in the Yukon River, when only 53 burbot were captured. This is well below the 290 burbot which were expected to be marked. Sampling which was planned during 1990 in the lower Tanana River in attempt to capture one of the burbot marked in the Yukon River will most likely be abandoned due to the large amount of effort which will be required.

DISCUSSION

Since this study was initiated in 1983, nearly the entire length of the Tanana River has been sampled, as well as many of the larger tributary streams. One of the major goals of this research was to identify existing stocks throughout the system. The sampling design used in this study has provided precise estimates of relative densities and length compositions. These estimates have shown that sizes and densities of burbot vary throughout the Tanana River system. In general, larger burbot are more predominant in lower (river

Table 5. Relative mixing rates[a] of burbot throughout ten sections of the Tanana River[b] and four tributary streams based on all recaptures obtained from 1983 through 1989.

Section Recaptured (Q_j)

Section Tagged (Q_i)	Tan1	Tan2	Tolov	Tan3	Tan4	Chena	Tan5	Tan6	Goodp	Tan7	Tan8	Tan9	Tan10	Chis
Tan1														
Tan2		0.714 0.034	0.143 0.020		0.143 0.020									
Tolov			0.50 0.25		0.50 0.25									
Tan3			0.154 0.010	0.214 0.013	0.429 0.019	0.071 0.005	0.154 0.010							
Tan4			0.007 0.001	0.007 0.001	0.866 0.001	0.007 0.001	0.047 0.001	0.047 0.001		0.020 0.001				
Chena					0.167 0.028	0.833 0.028								
Tan5					0.067 0.001	0.044 0.001	0.689 0.005	0.111 0.002		0.089 0.002				
Tan6								0.291 0.031		0.708 0.031				
Goodp														
Tan7									0.011 0.001	0.974 0.001	0.016 0.001			
Tan8											1.00 —			
Tan9												0.714 0.006	0.200 0.005	0.086 0.002
Tan10													0.861 0.003	0.139 0.003
Chis											0.027 0.001			0.973 0.001

[a] Relative mixing rates are shown as the top number in each box with the standard error printed below. The dark shaded boxes along the diagonal of the chart represent no movement. Boxes to the right of the diagonal indicate upstream movement, while numbers to the left of the diagonal indicate downstream movement.

[b] Each Tanana River section is approximately 90 km in length, with section 1 (Tan1) beginning at the mouth of the river and section 10 (Tan10) ending at the headwater streams. Tributary streams are shown at their relative location along the course of the Tanana River.

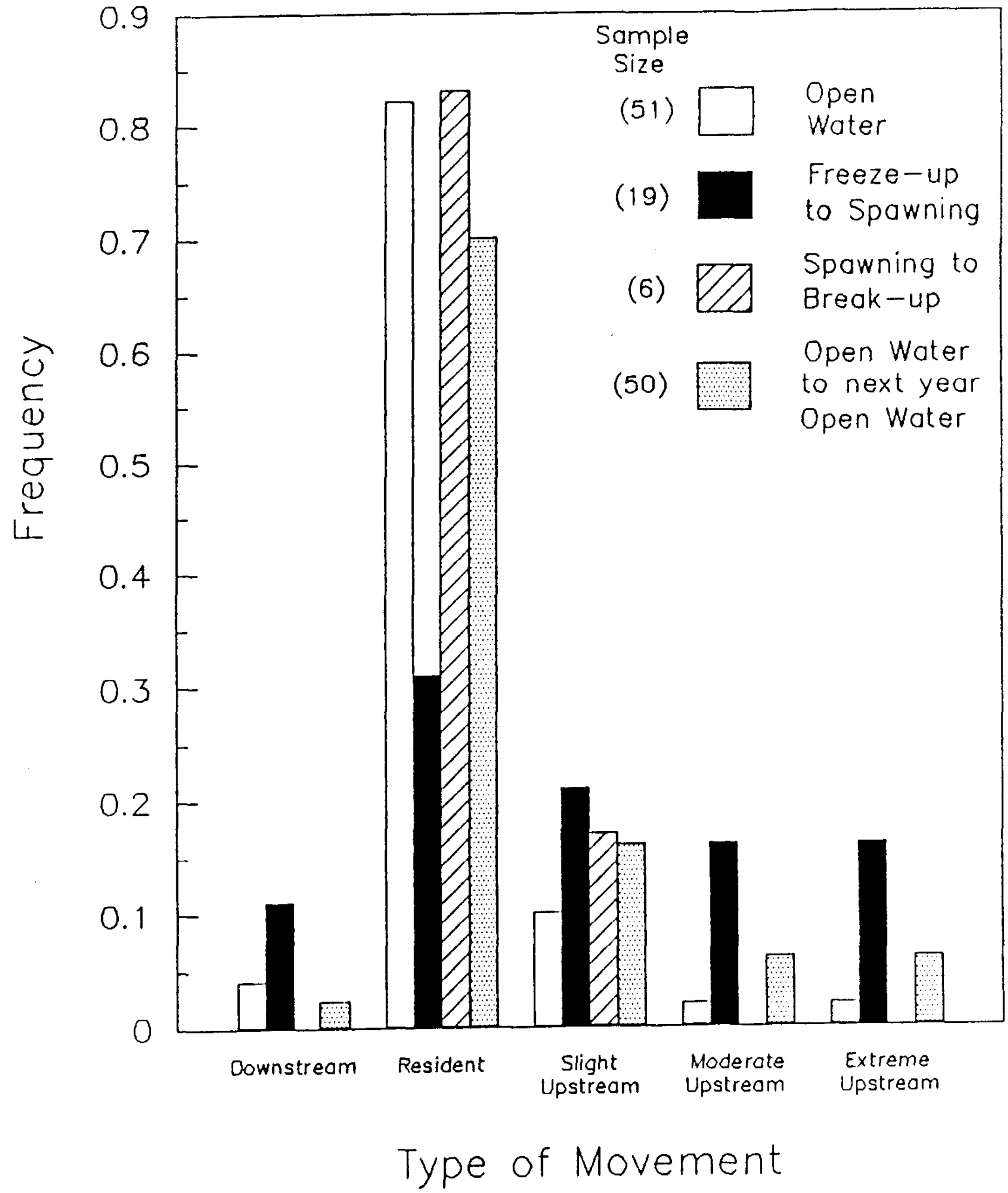

Figure 5. Seasonal movement rates of burbot in the Tanana River drainage.

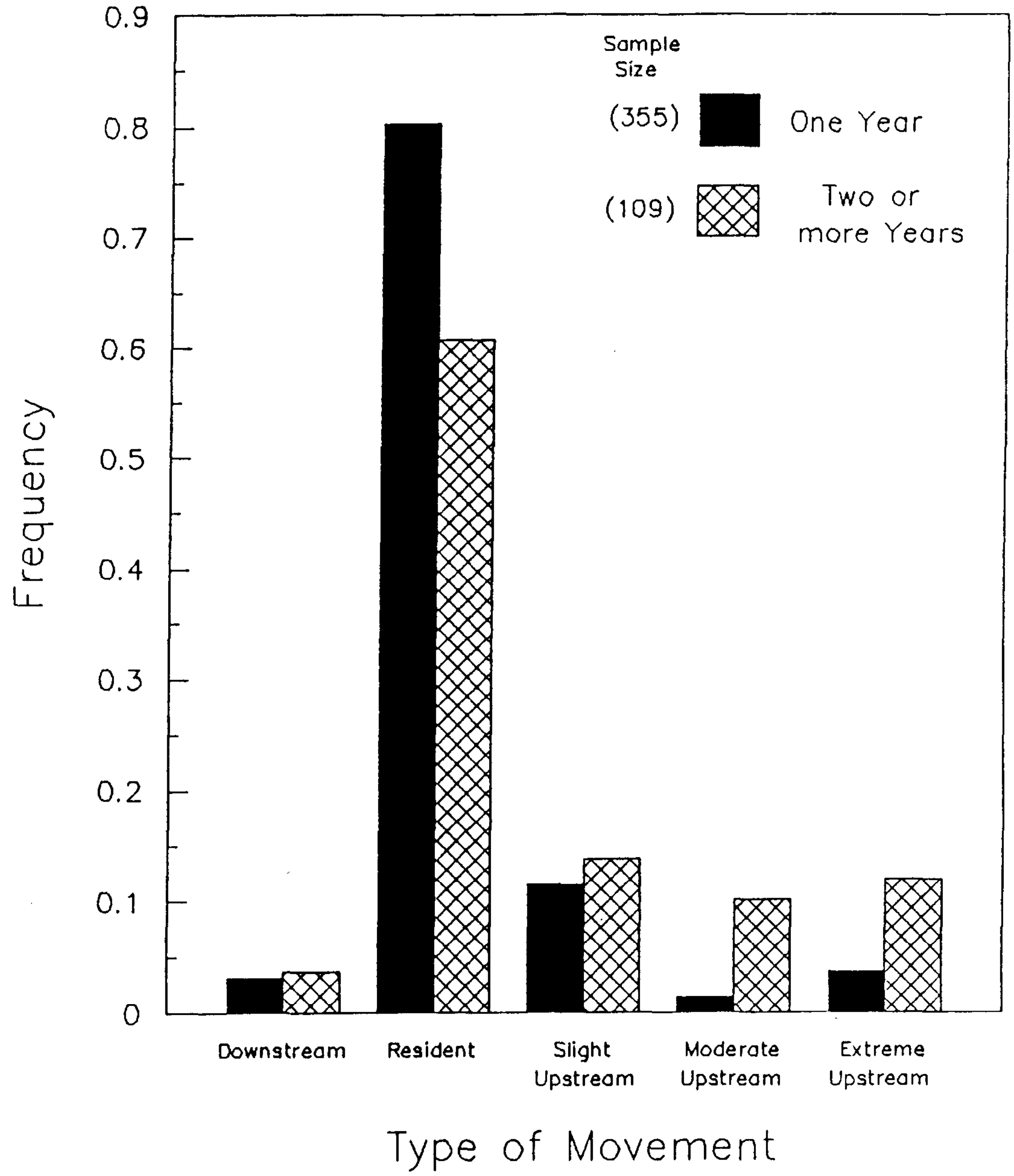

Figure 6. Annual movement rates of burbot in the Tanana River drainage.

kilometer 0 to 170) and upper (river kilometer 690 to 915) river areas than in middle river areas (Evenson 1989). Movement information from the 630 tag recoveries obtained have shown that a small proportion of burbot move considerable distances throughout the mainstem Tanana River, as well as into and out of tributary streams. This information supports a theory of a single stock existing in this system. Little is known about the movement behavior of larval and juvenile burbot in this system, although Volodin and Ivanova (1969) reported that young burbot in rivers are carried downstream from spawning areas by the current. The locations of spawning sites throughout this system are also for the most part unknown. Breeser et al. (1988) documented two possible spawning areas in headwater tributary streams of the Tanana River. However, more information regarding spawning locations is needed before accurate stock identification can be made.

The primary method for assessing stock status in this study is to obtain CPUE and length distribution estimates for sample sections throughout the system and to compare these estimates to previous years' data. However, accurate information regarding long-term movements is needed to interpret any changes in these estimates from one year to the next. Information to date suggests that a high proportion of burbot remain resident to a given area between annual sampling events, but that this proportion is lower two or more years later. The observed proportion of burbot remaining resident to an area may be artificially high due to sampling design. Because most of the tag recoveries have come from areas which have been sampled successively in the past, the probability of recapturing a burbot which was tagged in those sections is greater than the probability of recapturing a burbot which had moved in from another section. Therefore, these proportions of burbot remaining resident to various areas can be considered maximum estimates. In most all cases when movement out of a sample section occurs it is in an upstream direction. There appears to be no differential movement between burbot of different lengths (Evenson 1988).

The highest frequency of movements within a year's time occur during the period between river freeze-up and spawning. Movements of burbot during the spawning period are well documented (Breeser et al. 1988; Muth 1974; Sorokin 1971), although movements prior to spawning for feeding may also occur (Sorokin 1971; Volodin and Ivanova 1969). Because all tagging has been conducted during open water periods, it is difficult to interpret exactly when or over what period of time these spawning movements take place. It is not known whether burbot home to natal areas for spawning. However, because of the high proportion of burbot which are resident to an area during and between summer sampling events, it appears that burbot return to these areas following a spawning movement. These spawning movements coincide with the period when most of the harvest occurs. Because burbot have been recaptured in the Fairbanks area near the time of spawning, it is probable that spawning occurs in this vicinity.

Comparisons of CPUE and length distribution estimates of burbot sampled near Fairbanks over the last two years indicate that the relatively large harvest in this area has not significantly affected the proportion of burbot which are likely year-round residents to this area. The high degree of movement which occurs during this time seems to minimize the impacts of this concentrated harvest on local summer-resident stocks. To accurately assess the overall impact of this harvest, successive annual sampling should also be conducted in sections downstream and upstream from the Fairbanks area as this harvest most likely affects burbot which would have moved to these areas to oversummer.

Attempts to determine whether burbot migrated from the Tanana River into the Kantishna River were unsuccessful. Densities of burbot in the Kantishna River were much lower than adjacent waters of the Tanana River as well as other tributaries such as the Tolovana and Chena rivers. Migrations of burbot into many tributary streams from the Tanana River have been documented including one migration into the Nenana River which is a glacial river similar in characteristics to the Kantishna River. Because fishing pressure in the Kantishna River is minimal, and catch rates are low, future sampling is not warranted.

Catch rates in the Yukon River near the confluence of the Tanana River were also quite low. Low catch rates were also observed in another section of the Yukon River near the Dalton Highway Bridge (Figure 2) during 1988. Sampling in both sections was conducted in late August. Reports from anglers have indicated that catches in the Yukon River may be higher just prior to river freeze-up in mid October. Sampling during this time should be conducted in future studies to determine if hoop trap catch rates are significantly higher than summer catches.

MANAGEMENT RECOMMENDATIONS

Research concerning stock status in this system and the effects of harvest on these stocks is somewhat qualitative. Although precise estimates of CPUE and length distributions have been made for many sections throughout this system, quantitative comparisons of these estimates from one year to the next are difficult to interpret. Accurate assessment of changes in CPUE in sampling index areas from one year to the next are influenced by the following parameters: 1) natural mortality; 2) mortality through harvest; 3) emigration of burbot from the area; 4) immigration of burbot into the area; and, 5) recruitment through growth. Sampling is conducted exclusively during open-water periods, while harvest occurs primarily during the period from river freeze-up to spawning. Once accurate information regarding seasonal and long term movements of burbot is obtained, estimates of immigration and emigration rates of burbot into and out of index areas from one year to the next as well as the proportion of the winter harvest affecting summer resident burbot in these index areas can be determined. Once these estimates are known, then estimates of CPUE can be assessed more accurately, and estimates of natural survival and mortality within an index section can be attempted.

The relationship between CPUE and actual abundance is not clearly understood. During 1987, two population estimates were performed in the mainstem Tanana River (Evenson 1988). These two sections had mean CPUE estimates of 0.85 and 6.25 (burbot per net-night), while the actual abundance estimates were 159 and 279 (burbot per river kilometer) respectively. Thus, the dramatic difference in CPUE did not reflect a proportional difference in abundance. The effect of variables such as time of sampling and water levels on CPUE estimates are also not understood. Studies conducted by ADFG concerning CPUE for burbot in lakes of interior Alaska have shown that time of sampling has a dramatic effect on the magnitude of these estimates (Parker et al. 1988). Future research should be targeted toward assessing the value of CPUE as a reliable index of abundance, and obtaining more precise estimates concerning proportions of annual and seasonal movements into and out of sampling areas. Radio telemetry should be considered as a tool to more accurately determine seasonal movements of burbot throughout the summer sampling period as well as during the winter set-line fishery. A study of this type might also be useful in locating spawning sites throughout the river.

Harvest information from the annual Alaska Statewide Harvest Survey (Mills 1989) is very valuable, but incomplete. Because of the nature of this sport fishery, on site creel censusing is difficult and labor intensive. Thus, many of the characteristics of the fishery have not been quantified. Many of these characteristics such as where and when most fishing effort occurs, what proportion of the harvest comes from set-lines, what the average number of set-lines is per angler day, and CPUE information would be extremely valuable for better management of this fishery. A mail-out survey would be an effective way to obtain this information as well as to gather angler opinions concerning regulation changes should the need arise.

To date, the most effective tools for management of burbot populations in this system have been harvest information from the statewide harvest survey, abundance estimates performed in 1987, CPUE and length distribution estimates obtained throughout the system, and movement information from tag recoveries. This information has indicated that this large, open system contains an extremely large population of burbot relative to current harvest levels. Extensive movements occur throughout this system, and they are most frequent during the winter set-line fishery. This information implies that current annual harvests of 5,000 burbot or less most likely do not have a detrimental effect on these populations. Although effort and harvest have remained relatively stable over the last eight years, the liberal daily bag and possession limit of 15 burbot leaves open the possibility for a substantial increase in harvest should effort increase dramatically. Although the population as a whole could most likely sustain a large increase in harvest, the possibility of localized stock depletion in areas such as Fairbanks where concentrated fisheries occur is the primary concern. Accurate assessments of abundance in many river areas will be needed before sustained yield can be determined. To obtain this information extensive sampling effort will be required, and the cost-effectiveness of this sort of sampling endeavor should be considered. Monitoring of winter set-line catches in the Fairbanks area over the past three years, although limited, have not revealed a decline in angler catch rates or size compositions. Comparative estimates of CPUE and length distributions over the last two years in the Fairbanks area also do not indicate any detrimental effects of current harvest levels. Therefore, at this time there is no evidence to indicate that regulation changes for this fishery are needed.

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